4

CUTOFF +10.00 ft.

ROLLER REF.
POINT +7.0 ft.

ROLLER

GROUND SURFACE +4.00 ft.

100 YEAR SCOUR +1.50 ft.

BATTER RATIO 6:1

Length of Pile = 50'
Cutoff El. = +10.00'
Reference El. = +7.00'
Ground surface El. = +4.00'
Length of pile below Ref. = 37.50'
Scour El. = +1.50'
Batter = 5 :1
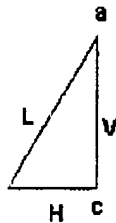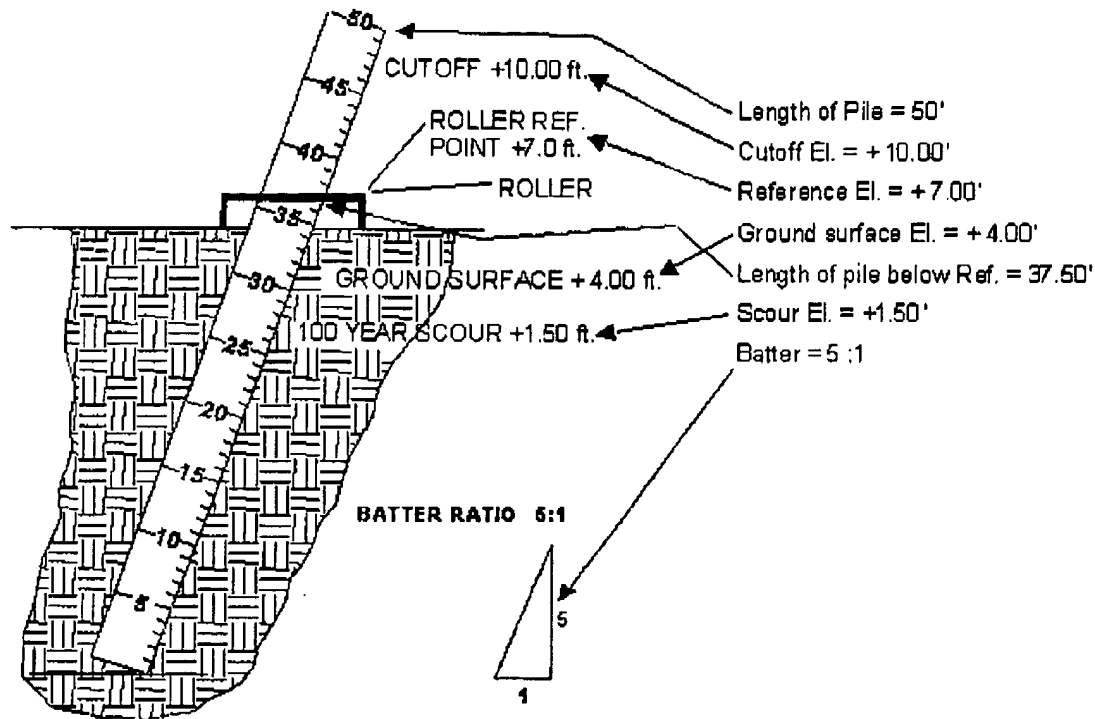
Batter Ratio = V/H or V:H

Definitions:

L = Pile Length Below Reference Point (ft)
a = Reference Point Elevation (ft)
V = Corrected Pile Depth (ft)
C = Pile Tip Elevation (ft)

Formulas:

$V = L*R$
$c = a - W$

Batter Ratio (V:H)	Correction Factor (R)
12:1	0.997
10:1	0.995
12:2 (6:1)	0.986
10:2 (5:1)	0.981
12:3 (4:1)	0.971
10:3	0.958
12:4 (3:1)	0.949
10:4 (5:2)	0.928
12:5	0.923

Therefore:

Don't forget to use the + & - signs for elevations. Also always do the work in the brackets () or [] before doing the calculation

Tip El. = TE
Ref. El. = +7.00'
Length Below Ref. = 37.5' Correction Factor = .981 (from table right)

TE = + 7.00' - [37.5' X .981] (Do the calculation In the [] prior to subtracting from +7.00')

TE = +7/00' - 36.78'
TE = -29.78'

Have You Reached the Minimum Penetration Requirements?

The Specifications set forth the minimum penetration requirements should the contract documents, plans or Driving Criteria Letter not specify a Minimum Tip Elevation or a Minimum Penetration.

"When the plans do not show a minimum depth of penetration, scour elevation, or minimum tip elevation, ensure that the required penetration is at least 10 feet into firm bearing material or at least 20 feet into soft material, unless otherwise permitted by the Engineer. If a scour elevation is shown in the plans, achieve these penetrations below the scour elevation..."

First, the Inspector must understand what the term "penetration" means.

Penetration- To obtain Penetration, *"Measure the penetration of piles from the elevation of natural ground, scour elevation shown in the plans, or the bottom of excavation, whichever is lower..."*
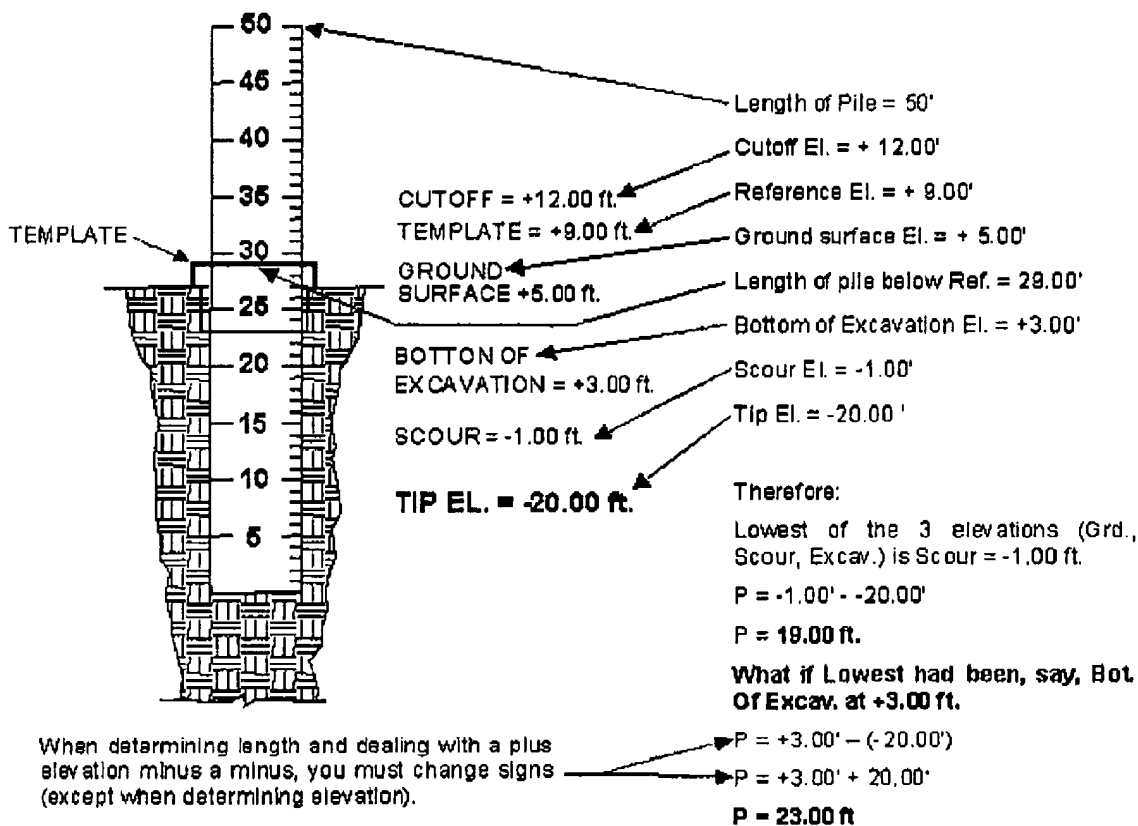
Next we will review how to calculate "Penetration for plumb and battered piles".

Has the pile achieved minimum penetration?

Calculation for Determining Penetration

For Vertical Pile (Illustration below)

Penetration (P) = Lowest of 3 elevations. - Tip Elev.

CUTOFF = +12.00 ft.
TEMPLATE = +9.00 ft.
GROUND SURFACE +5.00 ft.
BOTTOM OF EXCAVATION = +3.00 ft.
SCOUR = -1.00 ft.
TIP EL. = -20.00 ft.

TEMPLATE

Length of Pile = 50'
Cutoff El. = + 12.00'
Reference El. = + 9.00'
Ground surface El. = + 5.00'
Length of pile below Ref. = 29.00'
Bottom of Excavation El. = +3.00'
Scour El. = -1.00'
Tip El. = -20.00 '

Therefore:
Lowest of the 3 elevations (Grd., Scour, Excav.) is Scour = -1.00 ft.

P = -1.00' - -20.00'

P = 19.00 ft.

What if Lowest had been, say, Bot. Of Excav. at +3.00 ft.

P = +3.00' – (-20.00')
P = +3.00' + 20.00'

P = 23.00 ft

When determining length and dealing with a plus elevation minus a minus, you must change signs (except when determining elevation).

Battered Pile

Just as with Tip Elevations, the Penetration calculation for battered piles is essentially the same as vertical piles except that a Correction Factor is applied to compensate for the batter.

P = [Lowest of 3 Elevs (Grd. Surface, Scour, or Excavation).-Tip Elev.]/Corr. Factor

Using the illustration below and the information on the next page we know:

[See correction factor table, figure, definitions and formula from previous battered pile example]

Therefore:

P = [+1.5' - (-20.00')]/Correction Factor
P = +21.5'/.981
P = 21.91'

Have You met the Driving Criteria Specified by the Geotechnical Engineer?

The Driving Criteria, Blow Counts, set by the Geotechnical Engineer and presented in the Driving Criteria Letter, is what we are hoping to achieve in driving the pile.

Remember in the Test Pile Program section we discussed how the Geotechnical Engineer, based upon the driving of the Test Pile, developed these Blow Count Criteria.

More specifically, *Blow Count Criteria: The Engineer will determine the number of blows required to provide the required bearing according to the methods described herein. Determine the pile bearing by computing the penetration per blow with less than 1/4 inch [6 mm] rebound averaged through 12 inches [300 mm] each of penetration considered necessary by the Engineer. The Contractor may determine the average penetration per blow by averaging the penetration per blow through the last 10 to 20 blows of the hammer.*

So has the pile driving met the Driving Criteria for 2 consecutive feet?

Have You Reached Practical Refusal

Practical refusal is the point at which there is a great risk of damaging the pile should driving continue. This is generally caused by encountering dense material and more specifically:

Practical Refusal: Practical refusal is defined as 20 blows per inch [20 blows per 25 mm] with the hammer operating at the highest fuel setting or at a setting determined by the Engineer and less than 1/4 inch [6 mm] rebound per blow. Stop driving as soon as the Engineer determines that the pile has reached practical refusal. The Engineer will generally make this determination within 2 inches [50 mm] of driving. However, the Engineer will in no case approve the continuation of driving at practical refusal for more than 12 inches [300 mm]. When the required pile penetration cannot be achieved by driving without exceeding practical refusal, use other penetration aids such as jetting or Preformed Pile Holes.

Have you reached Practical refusal? **20 blows per inch**

Is the Pile Top Within 2 Feet of the Pile Cutoff Elevation?

For every foot the pile is driven, we are getting a foot closer to the Cutoff Elevation. Cutoff Elevation is *"The finished elevation of the pile top as shown in the plans."*

If the pile is driven past the Cutoff elevation, a splice will be required in most cases to get back up to the planned Cutoff elevation. So, as the pile approaches Cutoff, we may want to take advantage of performing a Set-Check, as prescribed following:

Set-checks and Pile Redrive:
(a) Set-checks: In the event that the Contractor has driven the pile to approximately 12 inches [300 mm] above cut-off without reaching the required resistance, the Engineer may require the Contractor to interrupt driving at least 15 minutes prior to performing a set-check. A set-check consists of ten hammer blows or 10 inches [250 mm] or more of driving. Provide an engineer's level or other suitable equipment for elevation determinations to determine accurate pile penetration during the set-checks. There will be no separate payment for an initial set-check. In the event the result of an initial set-check is not satisfactory, the Engineer may direct additional set-checks. For each additional set-check ordered by the Engineer within 72 hours from the end of original driving, the Contractor will be paid an additional quantity of 10 feet [3 m] of Piling. The Engineer may accept the pile as driven when a set-check shows that the Contractor has achieved the minimum required pile bearing and has met all other requirements of this Section...

Is the pile within 2 feet of Cutoff?

Next we will review how to calculate this target.

Calculation for Determining Proximity to Cutoff Elevation

This is the same calculation that you performed in the "Begin Pile Driving" section for the "Stop for Set check Target". Remember:

<u>For Vertical Pile</u> (Illustration to right)

Calculation

CO = Pile Length – 2' – (Cut-off Elev. – Ref. Elev.)

Therefore;

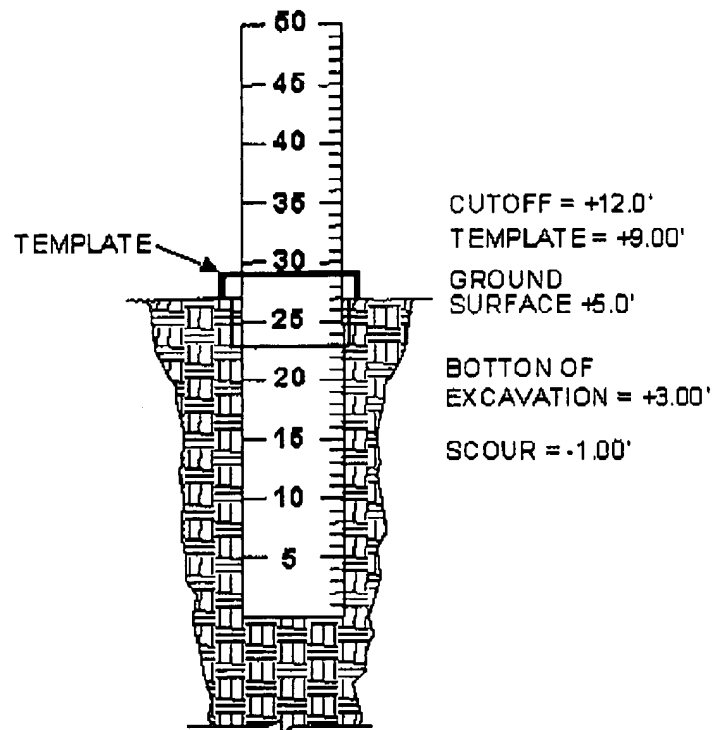50'- 2' – (+12.00' - +9.00')- Remember, always do the function in brackets first

50'- 2' – (3')

48' – 3' = 45'

= 45.00 feet

Therefore the 45 foot mark on the pile is 2 feet above Cutoff elevation.

<u>For Battered Pile</u>

CO = Pile Length – 2' – [(Cut-off Elev. – Ref. Elev.) + Corr. Factor]

CUTOFF = +12.0'
TEMPLATE = +9.00'

GROUND
SURFACE +5.0'

BOTTON OF
EXCAVATION = +3.00'

SCOUR = -1.00'

TEMPLATE

Length Driven

Though not one of the questions for "When to Stop", it is important that an Inspector know how to determine Length Driven.

Length driven is not a required length to know in the newest specifications, however, there will be projects let for years that are designed with the 2000 or earlier versions of the specifications that includes this. For those projects, you will need to know how to determine length driven.
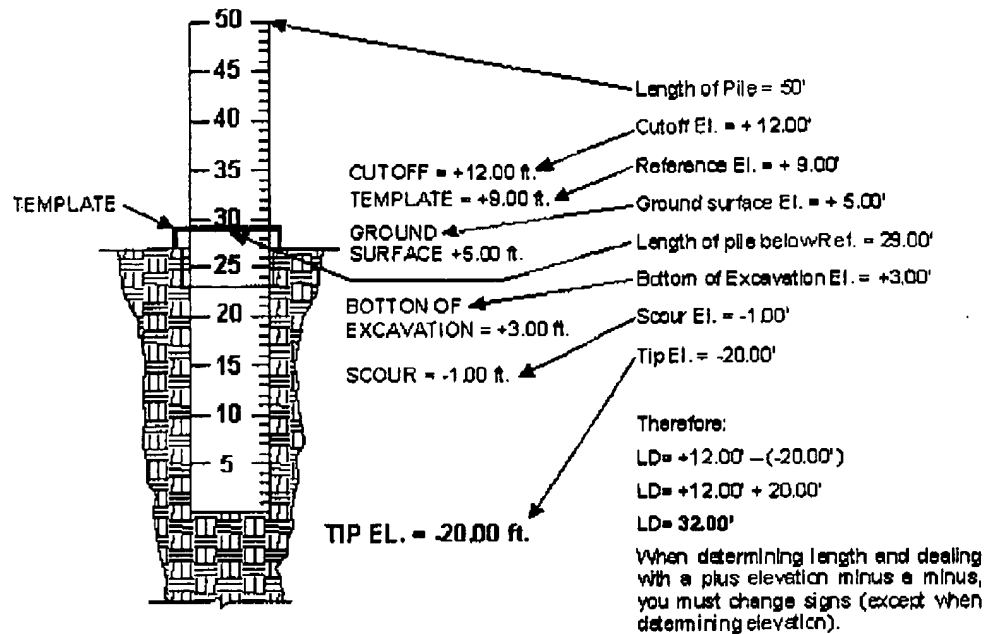
Calculation for Determining Length Drive

For Vertical Pile

Using the illustration below, we know:

Length Drive (LD) = Cutoff Elev. - Tip Elev.

CUTOFF = +12.00 ft.
TEMPLATE = +9.00 ft.
GROUND
SURFACE +5.00 ft.

BOTTON OF
EXCAVATION = +3.00 ft.

SCOUR = -1.00 ft.

TEMPLATE

TIP EL. = -20.00 ft.

Length of Pile = 50'
Cutoff El. = +12.00'
Reference El. = +9.00'
Ground surface El. = +5.00'
Length of pile below Ref. = 29.00'
Bottom of Excavation El. = +3.00'
Scour El. = -1.00'
Tip El. = -20.00'

Therefore:

LD = +12.00 – (-20.00')

LD = +12.00 + 20.00'

LD = 32.00'

When determining length and dealing with a plus elevation minus a minus, you must change signs (except when determining elevation).
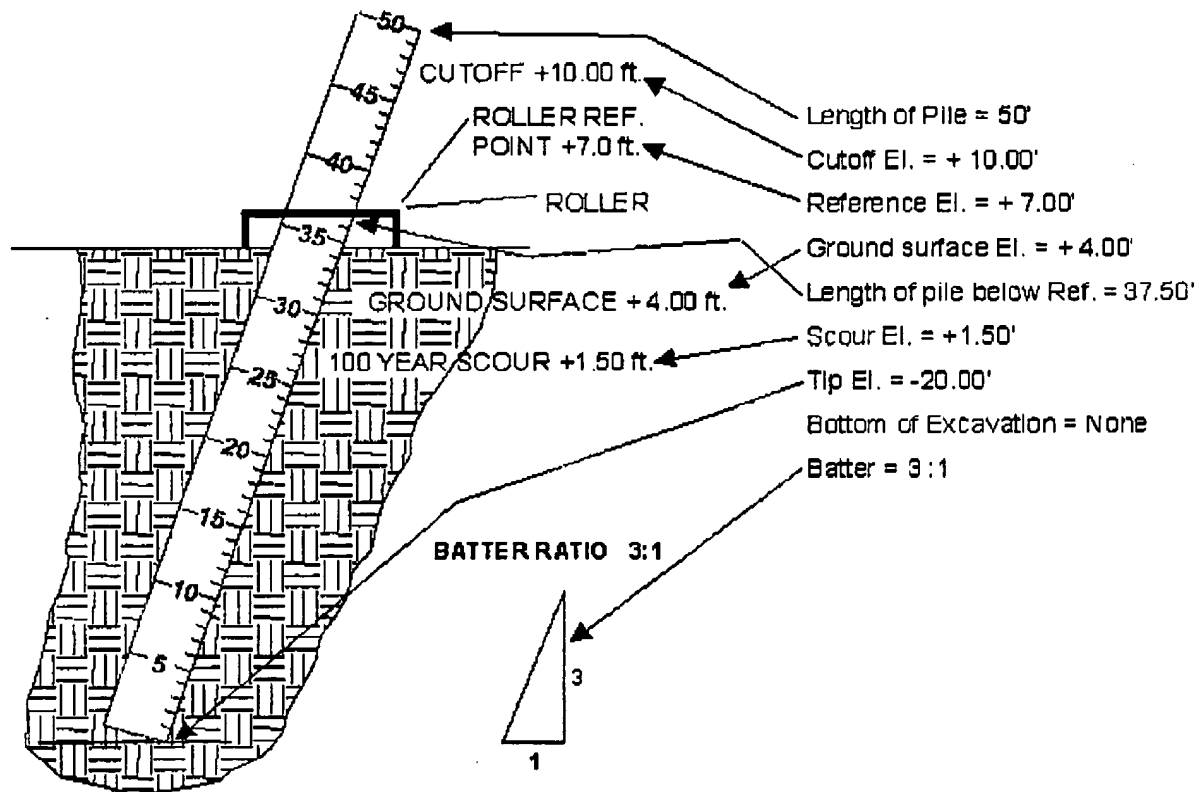
For Battered Pile

Using the illustration below and the information on the next page, we know:

LD = [Cutoff Elev. - (Tip Elev.)]/Correction Factor]

CUTOFF +10.00 ft.
ROLLER REF.
POINT +7.0 ft.
ROLLER
GROUND SURFACE +4.00 ft.
100 YEAR SCOUR +1.50 ft.

BATTER RATIO 3:1

Length of Pile = 50'
Cutoff El. = +10.00'
Reference El. = +7.00'
Ground surface El. = +4.00'
Length of pile below Ref. = 37.50'
Scour El. = +1.50'
Tip El. = -20.00'
Bottom of Excavation = None
Batter = 3:1

(See correction factor table, figure, definitions and formula from above battered pile example)

Therefore:

LD = [+10.00' - (-20.00')]/.949
LD = 30.00'/.949
LD = 31.61'

Don't forget to use the + & - signs for elevations. Also, always do the work in the brackets ( ) or [ ] before doing calculation.

This page last modified on May 9, 2006